



I-WEST

Intermountain West Energy Sustainability & Transitions

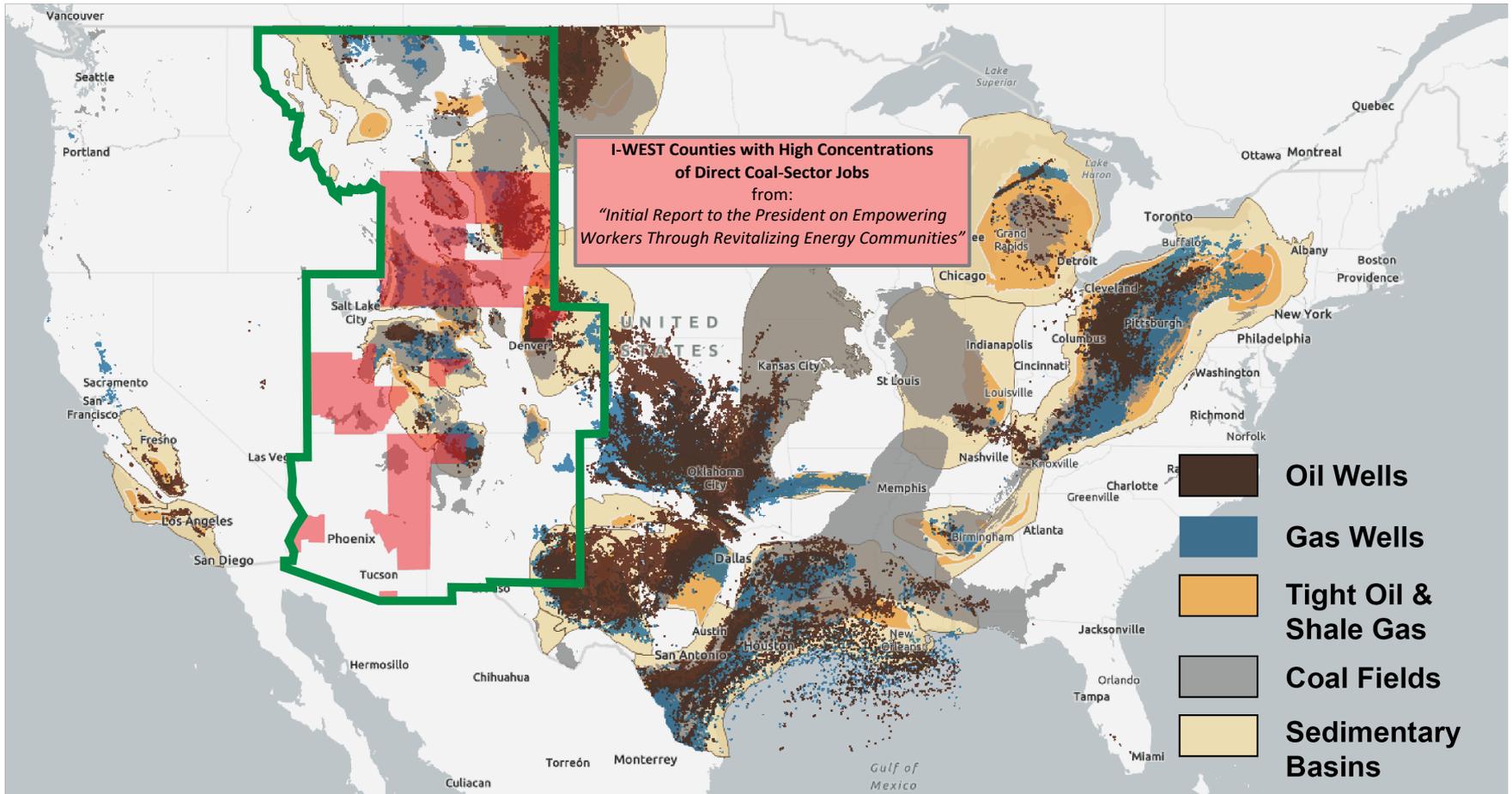
A Place-based Approach to Achieving Carbon Neutrality in the Intermountain West

Quarterly Update
8 December 2021

LA-UR-21-31814



Why this region? I-WEST is a region with communities dependent on fossil-based economies.



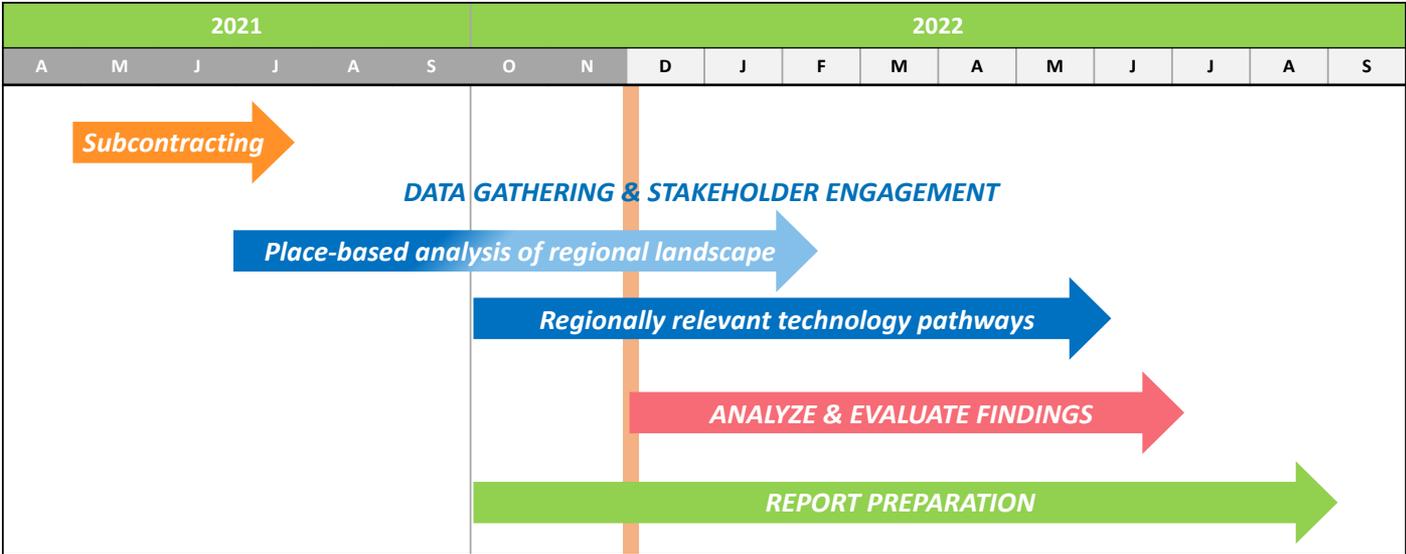
U.S. Fossil Fuel Resources (atlas.eia.gov)

Thumbnail of the I-WEST Phase I Assessment

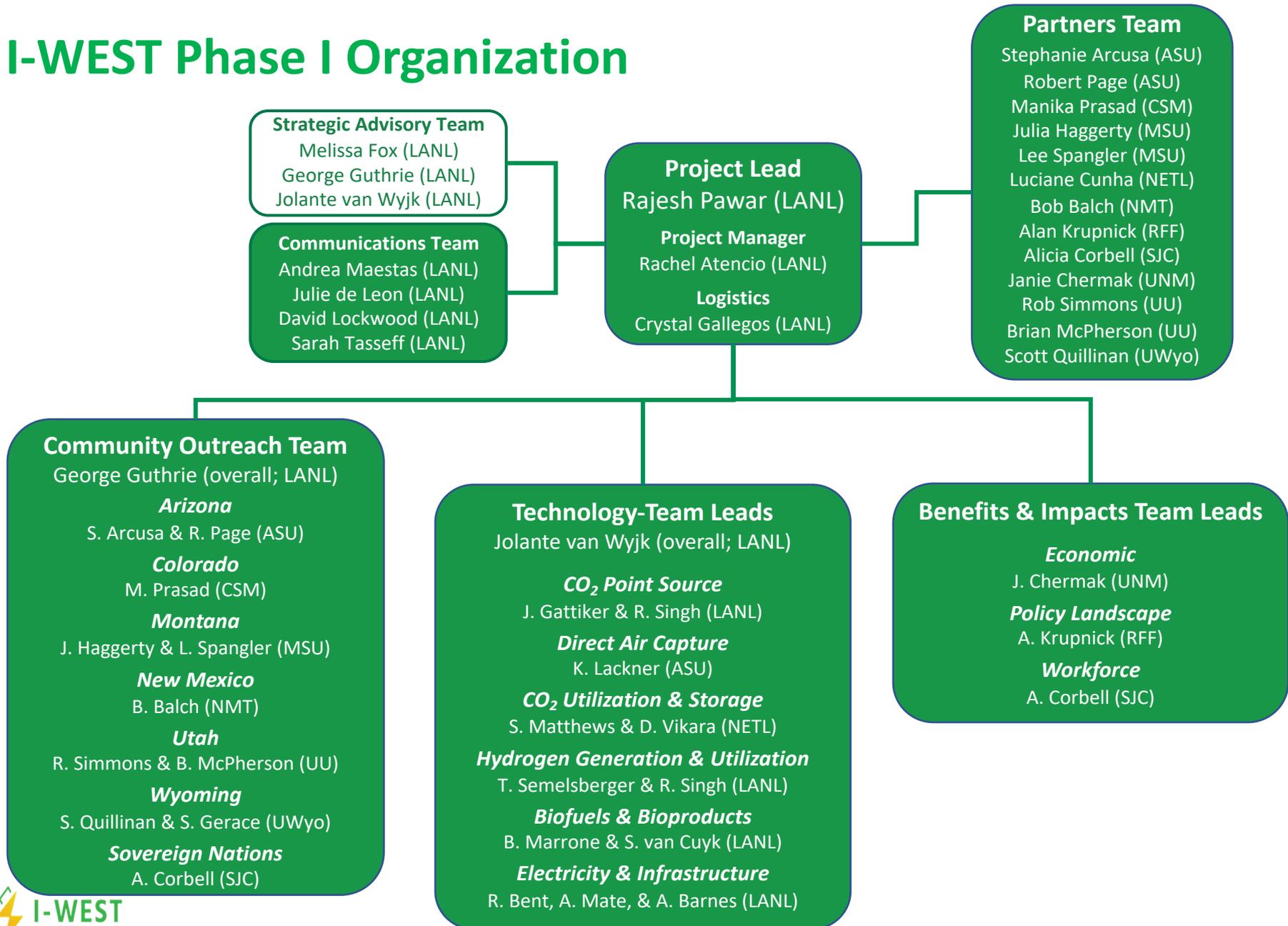


Objectives

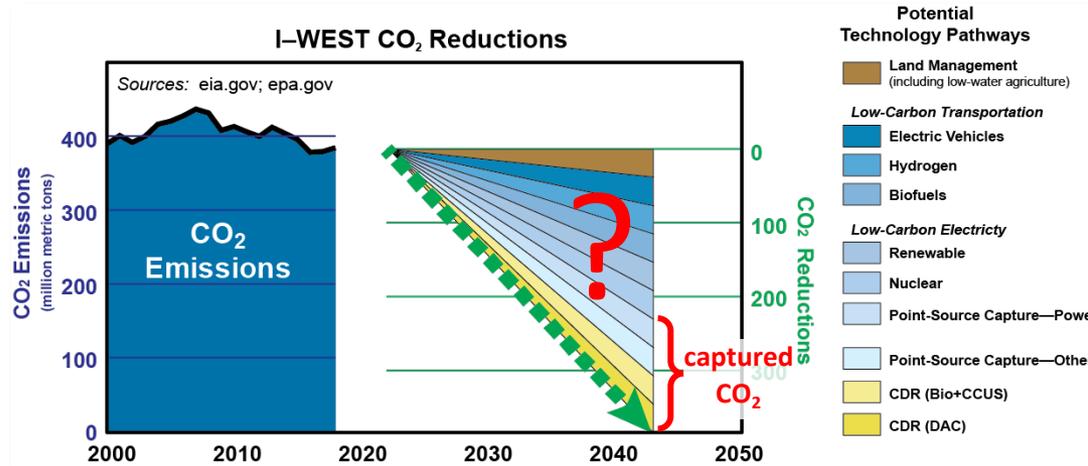
- To develop a regional, stakeholder-informed technology roadmap
 - Regionally relevant technology pathways
 - Options that can be deployed now & ones needed within next decade
 - Explicit consideration of equity, impact, workforce, etc.
- To facilitate regional coalitions to implement & deploy the roadmap



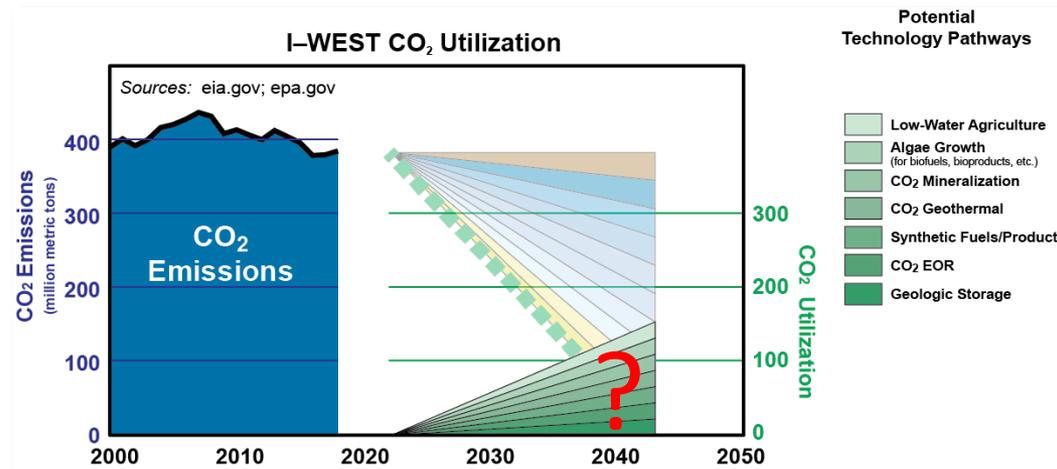
I-WEST Phase I Organization



Recasting Emissions Reductions into New Economies



- Multiple potential technology pathways will be explored & “quantified” relative to achieving CO₂ neutrality in the region
 - Pathways represent new regional economies
- Strategy must explicitly consider the interconnectivity of pathways relative to growth, resource needs, impacts, etc.

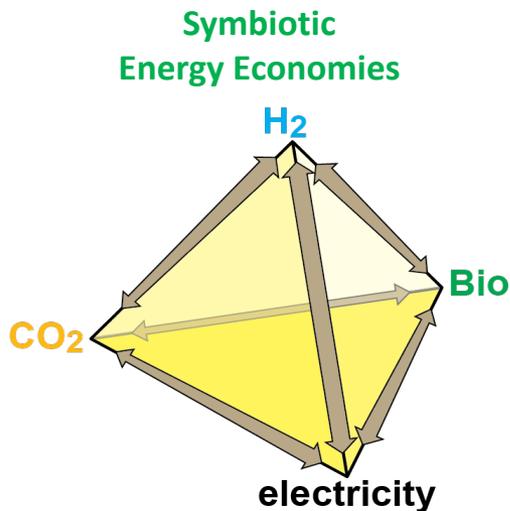


For example...

- Several pathways would produce a supply of captured CO₂
- Multiple potential technology pathways will be explored & “quantified” relative to creating a demand for captured CO₂ that aligns with the reduction strategy

What will the I-WEST roadmap contain?

Regionally Relevant Technology Pathways

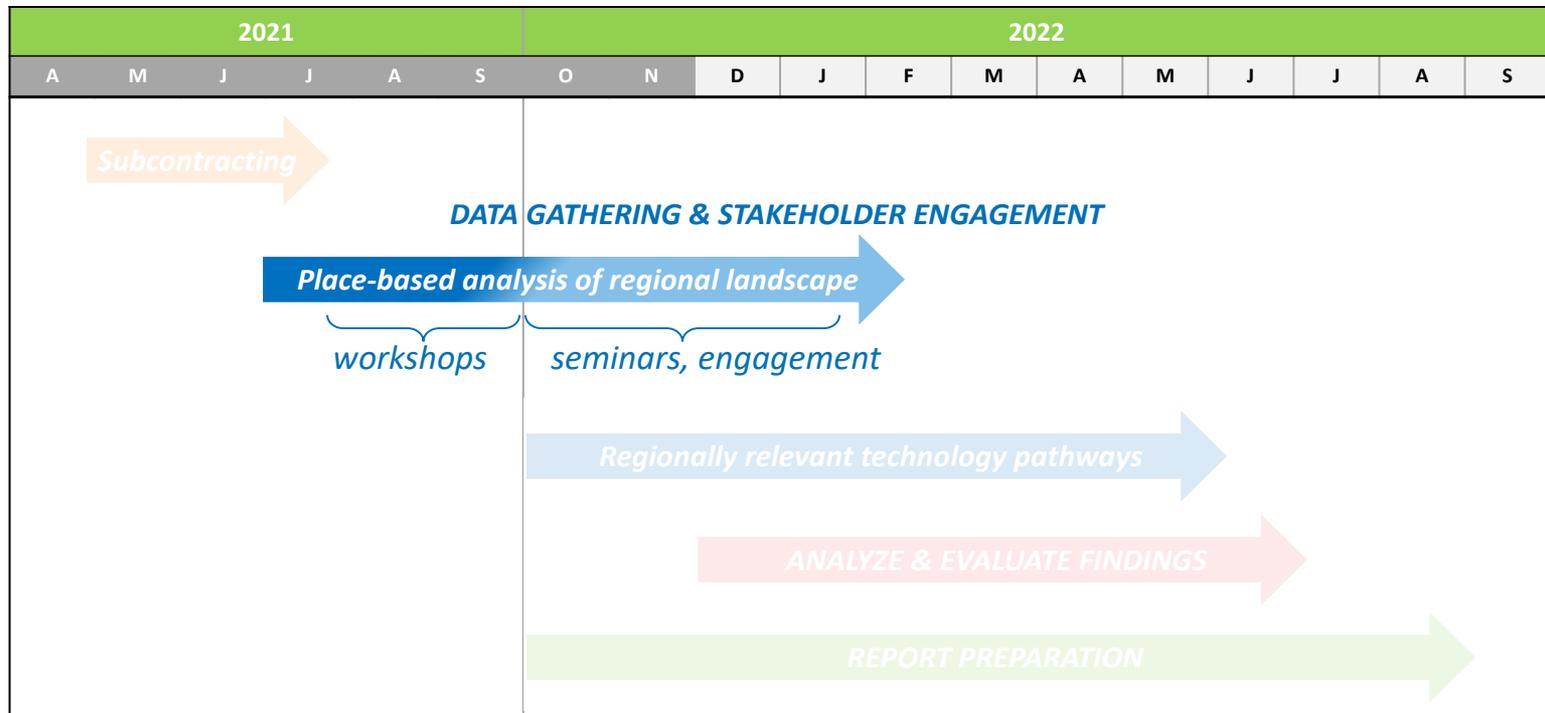


- Pathways will align with regional characteristics
- Stakeholder engagement will help to quantify pathways (“wedges”)
- Pathways will enable new, symbiotic energy economies
 - CO_2 capture (supply) and CO_2 storage and utilization (demand)
 - H_2 production (supply) and H_2 utilization (demand)
 - Biomass production (supply) and biomass utilization (demand)
 - Carbon-neutral electricity production (supply) and utilization (demand)

Pathway Details

- Technology maturation (R&D) needed to enable deployment (if applicable)
- Non-technological impediments to deployment (opportunities/strategies to address)
- Impact of pathways (ESJ, workforce, revenue, tax base, etc.)

Understanding the regional diversity is the focus of our phase-I outreach and central to “place-based”.



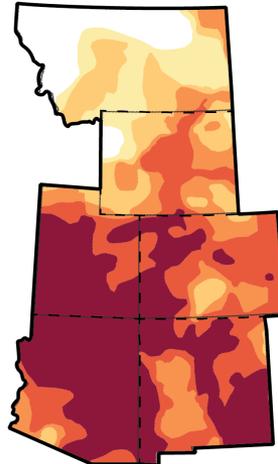
Intermountain West region has a diversity of attributes.



U.S. Domestic Sovereign Nations

Sources:
Bureau of Indian Affairs
Office of Trust Services
2017
(<https://biampaps.doi.gov>)

- American Indian Tribes
- Trust or Restricted Fee

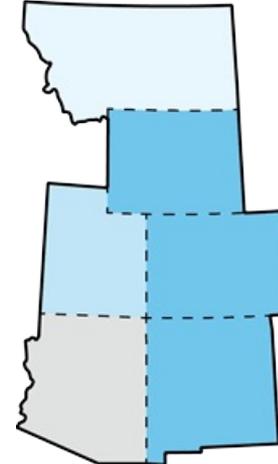


Drying U.S. West

Period: 2020
Source: NASA
Earth Observatory
(<http://earthobservatory.nasa.gov>)

Drought Intensity

- Abnormally Dry
- Moderate Drought
- Severe Drought
- Extreme Drought
- Exceptional Drought

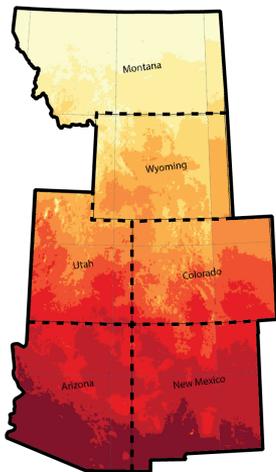


Annual Dry Gas Production

Period: 2019
Source: U.S. Energy
Information Administration
(<http://eia.gov>)

Dry Gas Production (BCF)

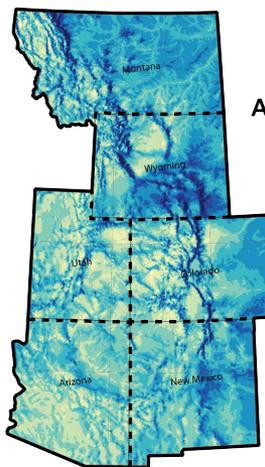
- 0
- <100
- 100–1000
- 1000–2000



Global Horizontal Solar Irradiance

Period: 1961–1990
Source: Roberts (2018)
(<https://www.nrel.gov>)

- GHI (kWh/m²/d)
- ≥5.75
 - 5.50–5.75
 - 5.25–5.50
 - 5.00–5.25
 - 4.75–5.00
 - 4.50–4.75
 - 4.25 to 4.50
 - 4.00 to 4.25

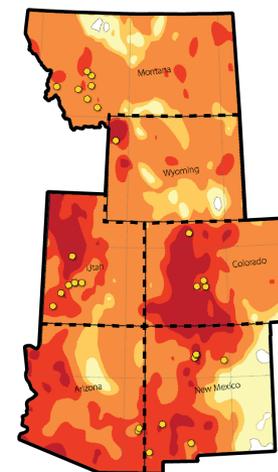


Average Wind Speed (at 80-m; 2007–2013)

Source:
Roberts (2017)
(<https://www.nrel.gov>)

Wind Speed (m/s)

- ≥10
- 9.0–9.9
- 8.0–8.9
- 7.0–7.9
- 6.0–6.9
- 5.0–5.9
- 4.0–4.9
- 3.0–3.9
- <3.0



Geothermal Resource Potential

Source:
Roberts (2009)
(<https://www.nrel.gov>)

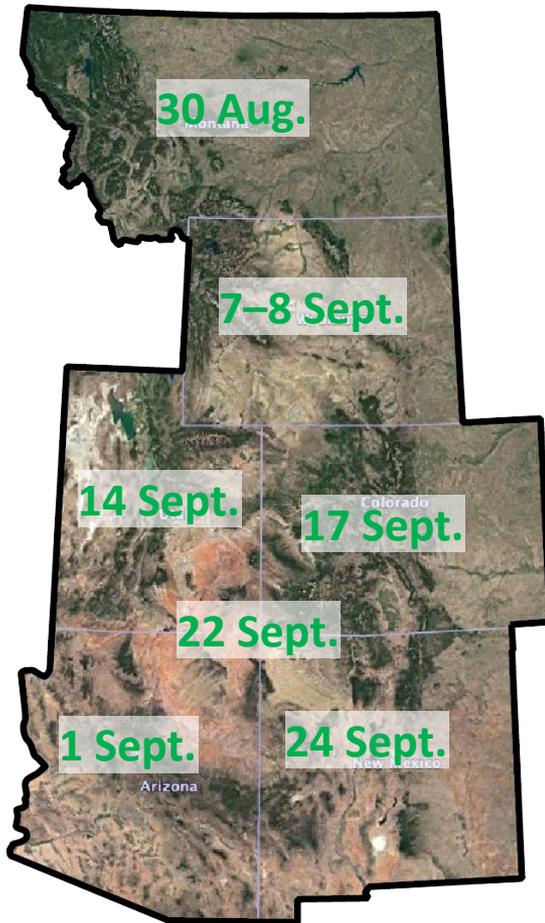
Favorability of Deep Enhanced Geothermal Systems

- Most Favorable
-
-
-
- Least Favorable
- N/A (T<150°C @ 10-km depth)
- Identified Hydrothermal Site (≥90°C)

The new energy infrastructure and economies must anticipate the evolution of the region in response to climate change.

The first step in regional engagement was a series of workshops focused on States & Sovereign Nations.

Initial state-focused workshops were held in late summer 2021.



Community Outreach Strategy

- Engage stakeholders through workshops, surveys, and other
 - Identify expectations—needs, goals, concerns; community through regional scale

Insights from Initial Workshops

- Extensive emerging activity (projects; state-level), particularly in hydrogen (hub)
 - Opportunity for coordination & coalition-building
- Commonality in carbon-neutrality goal, but diversity in perspectives on how to get there
 - Shifted from “decarbonization” to “carbon-neutral”
- Focus on water is widespread
 - Implications for technologies
 - Opportunity for integrating “water” as part of the strategy
- Negative impacts emerging now

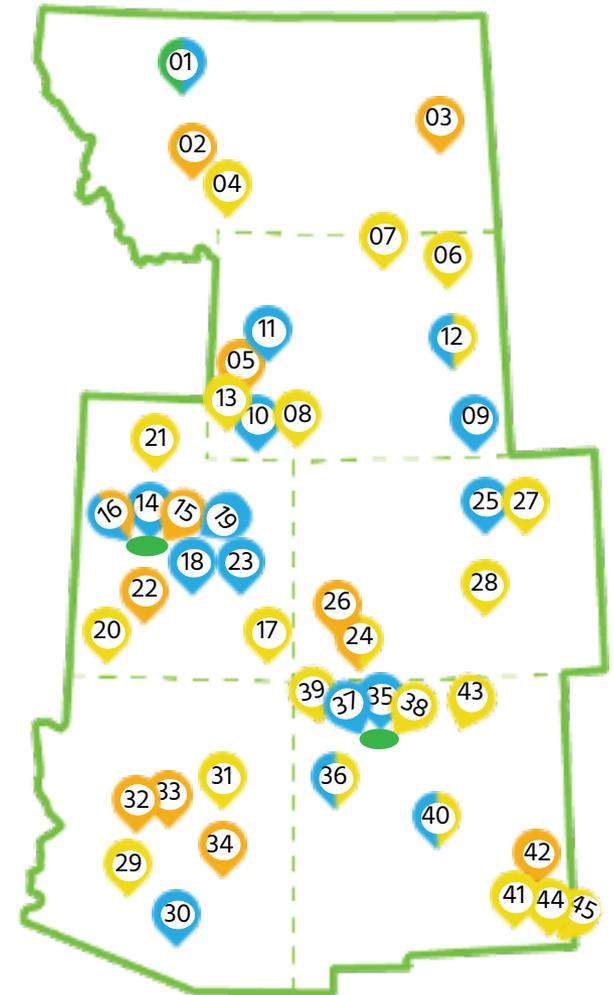
Workshops helped to identify emerging energy projects and other activity in the Intermountain West region.

I-WEST: Project Catalog

- | | |
|--|--|
| 1. Montana Renewables | 25. AAA Colorado |
| 2. Gordon Butte Pumped Storage | 26. Methane Capture Project |
| 3. ClearWater Wind Project | 27. Feasibility Study on a Potential CCS Project in Colorado CO2 Capture from a Refinery and Sequestration in the DJ Basin |
| 4. Planning Amongst Uncertainty Designing CCS Infrastructure Resilient to Capture, Transport and Storage Uncertainty | 28. LaFargeHolcim Portland Cement Plant |
| 5. Natrium Demo -Terra Power | 29. Direct Air Capture - Tree |
| 6. Wyoming CarbonSafe Project at Dry Fork Station | 30. Nikola |
| 7. The Carbon Valley | 31. Characterization of CO2 Storage Potential in Harquahala basin Western Central Arizona |
| 8. Rock Springs Uplift, Regional CCUS Hub | 32. KORE Power |
| 9. Black Hills Energy | 33. Arizona Peaking Capacity Energy Storage Project (AES Energy Storage, LLC) |
| 10. Williams Companies | 34. Lucid Motor |
| 11. Jonah Energy | 35. Libertad Power Project |
| 12. Project Blue Bison (Blue Hydrogen) | 36. Escalante H2 Power project |
| 13. LaBarge Carbon Capture project | 37. Hydrogen Pilot Project (Big Navajo Energy) |
| 14. Intermountain Power Project | 38. Enchant Energy |
| 15. Range Energy Storage Systems | 39. Oxy Low Carbon Ventures Direct Air Capture |
| 16. Magnum Development | 40. Conversion of Hydrogen from Natural Gas and Integration with CO2 Capture and Storage |
| 17. Aneth Field | 41. Jumpstarting Regional CCS through Co Optimized CO2 and Water Disposal |
| 18. Inland Port (Project Beehive) | 42. Prosperity Project |
| 19. Advanced Clean Energy Storage Project | 43. New Mexico CarbonSAFE |
| 20. CCS at the Iron Mountain Iron Mine and Direct Reduced Iron Processing Plant, | 44. Red Hills Facility Project |
| 21. Laboratory Feasibility Study for Eventual Field Deployment of a Downhole Source Tomographic Design for CO2 Plume Detection | 45. Oxy Hobbs Field CO2 EOR |
| 22. The Milford Wind Project | |
| 23. ThermH2-TM pilot project | |
| 24. Coyote Clean Power Project | |

Energy-related Economies

- Biomass—Production,, Use/Conversion
- H₂—Production, Use
- CO₂—Capture, Use, Storage
- Other



Additional outreach will engage stakeholders through topical seminars and workshops.

Monthly seminars are exploring cross-cutting challenges across the region; through the attendees, we are building our stakeholder registry.

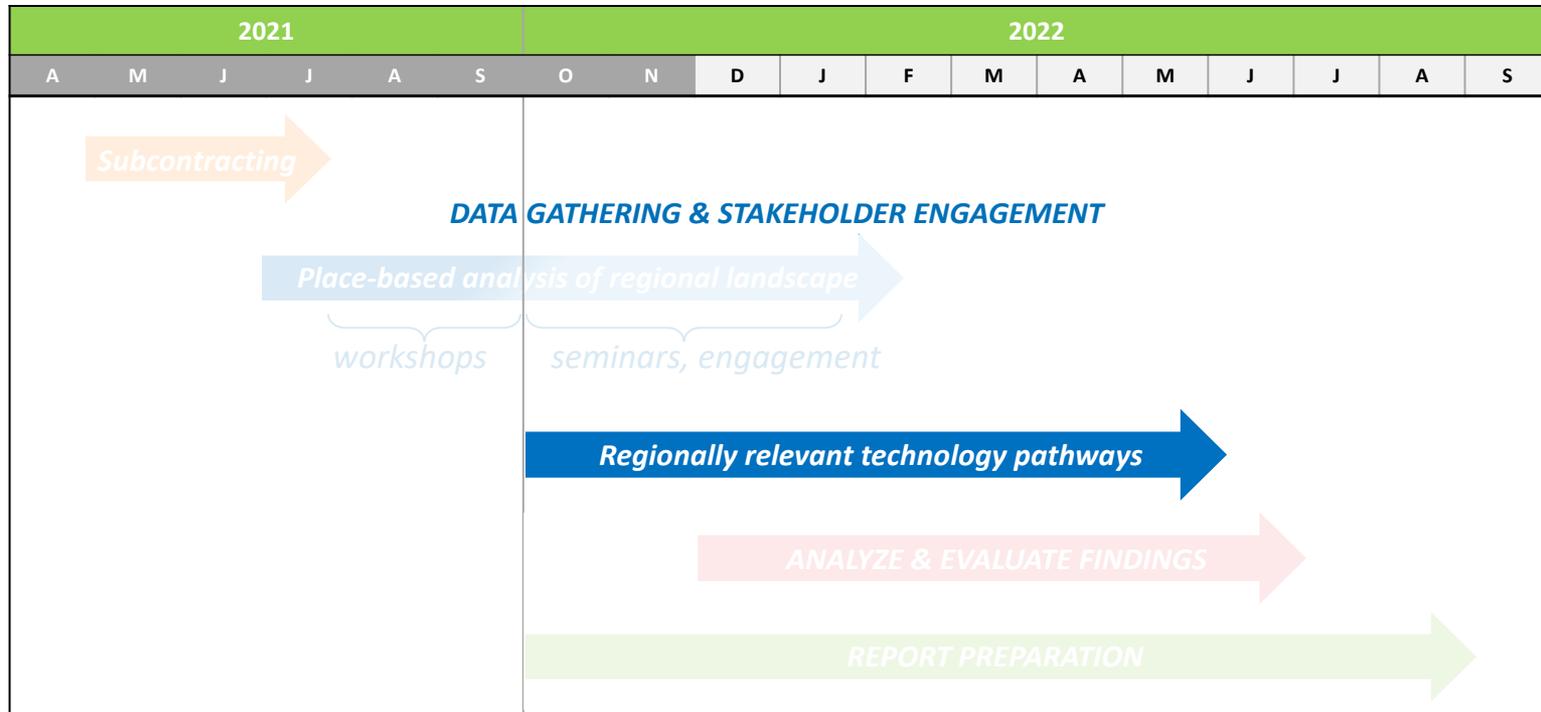
- *Gigaton Needs, Gigaton Challenges*
Melanie Kenderdine—30 Sept 2021
- *Western States and Tribal Nations Natural Gas Initiative*
Jason Sandel—18 Nov 2021
- *National Energy Modeling System (NEMS)*
José Benitez—20 Dec 2021
- *E3SM, SCREAM, and Climate Evolution in the Intermountain West*
Ruby Leung—TBD

The I-WEST team has been pursuing several ad hoc routes to extending our place-based understanding.

- **Stakeholder Registry**—the I-WEST team has been collecting stakeholders across the region from those who attend seminars and workshops. Currently ~400 in the registry.
- **Surveys, Focus Groups, Targeted Briefings**—the I-WEST team is testing various strategies for engaging regional stakeholders.
- **I-WEST Website**—the I-WEST website is being expanded to provide more comprehensive outreach content. Will be launched mid-December.

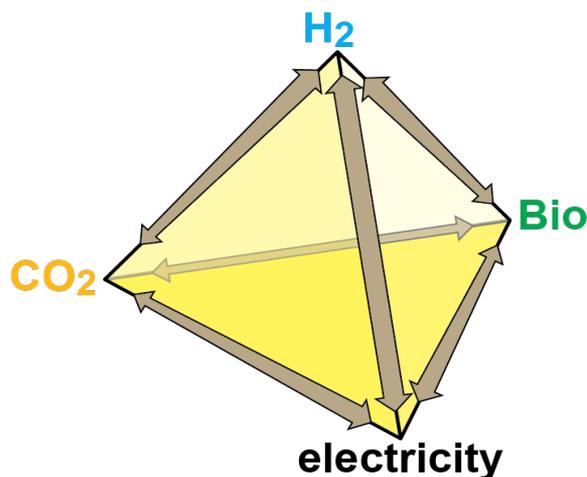


We are building the roadmap through stakeholder engagements to explore technology pathways.



Topical “workshops” will engage stakeholders across the region through spring 2022.

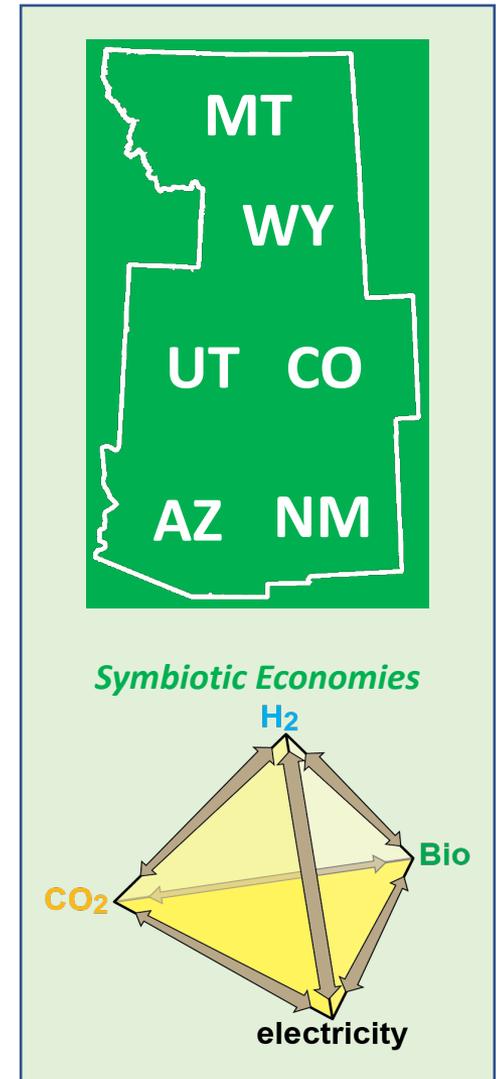
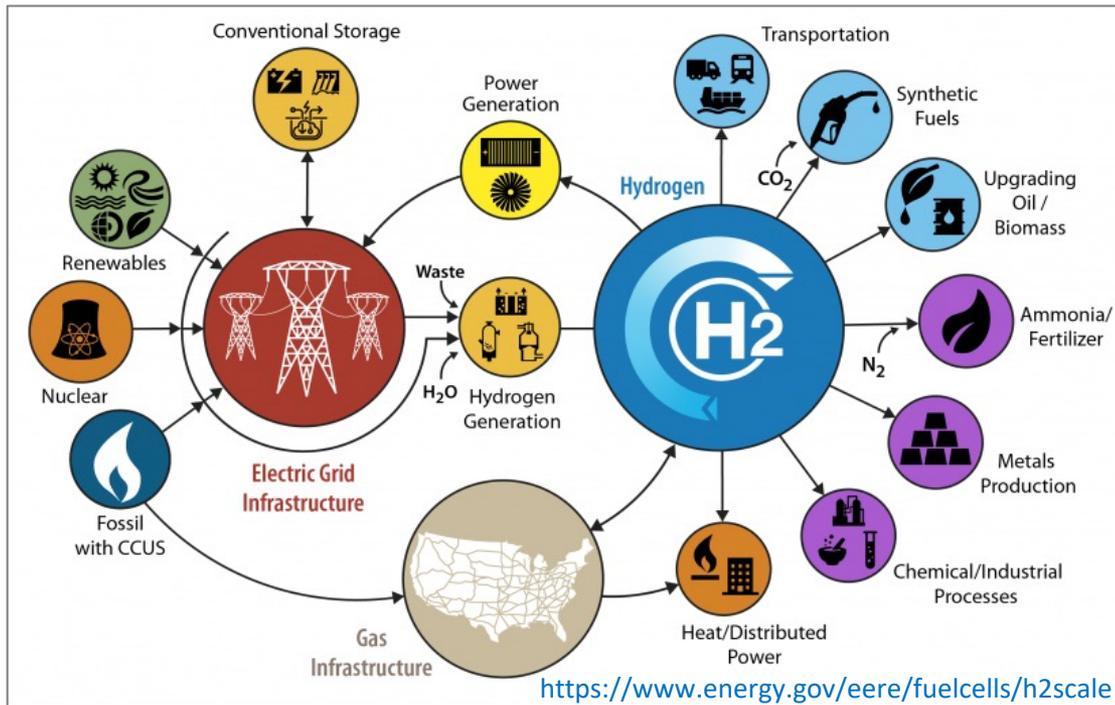
It is anticipated that many technology pathways will tie to a hydrogen economy.



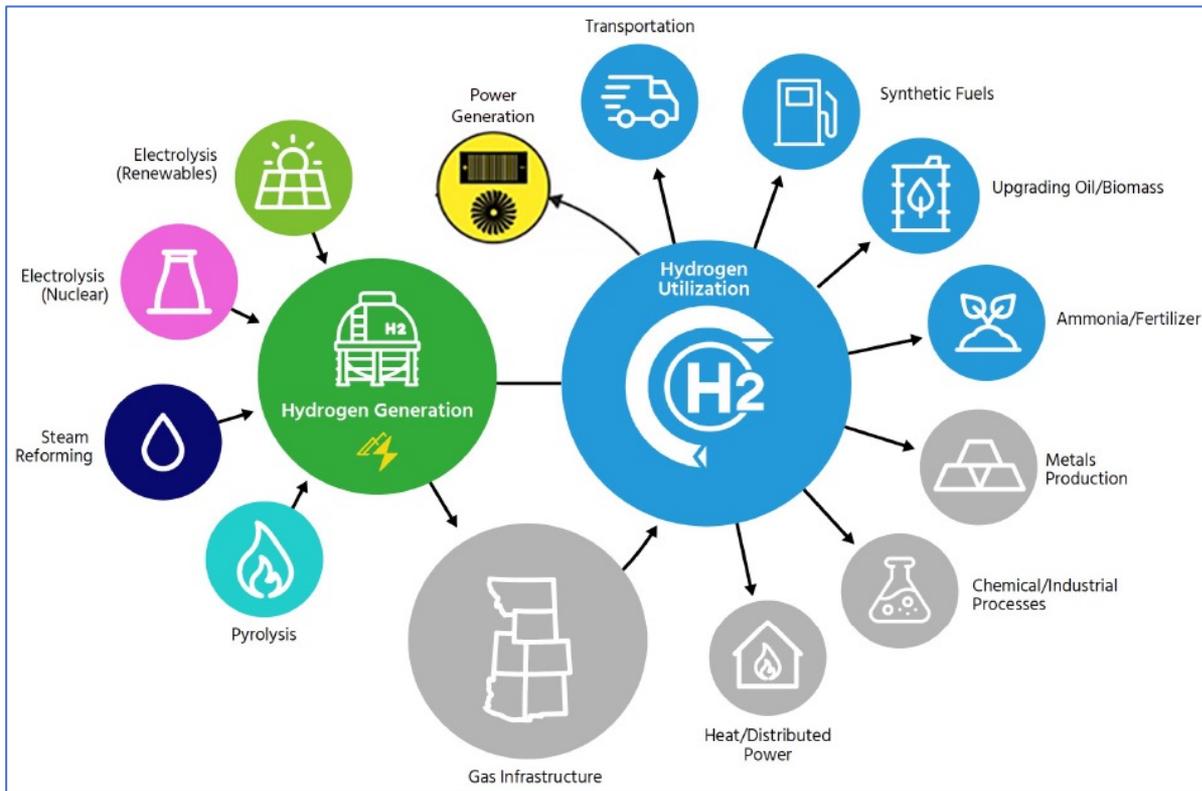
- Series of stakeholder engagements around technology pathways relevant to the region will target two goals:
 - Quantify the potential scale of the technology pathway relative to achieving carbon neutrality—i.e., technology “wedges”
 - Elucidate the technological and non-technological factors that could impede or facilitate the pathways
- Open capstone workshop will lay out the final pathway, built from input derived from “Chatham House Rule” events

- **CO₂ capture from point sources**—(first event 11/30/21)
- **CO₂ capture from the air**—(first event 1/19/22)
- **CO₂ storage & utilization**—(first event 12/14/21)
- **Hydrogen generation**—(first event 1/11/22)
- **Hydrogen utilization**—(first event 1/18/22)
- **Bioenergy**—(first event 1/25/22)
- **Biological CO₂ conversion & value-added products** — (first event 1/27/22)
- **Electricity generation**—(first event 2/8/22)

As a place-based initiative, I-WEST is adapting the national view of a hydrogen economy to the region.

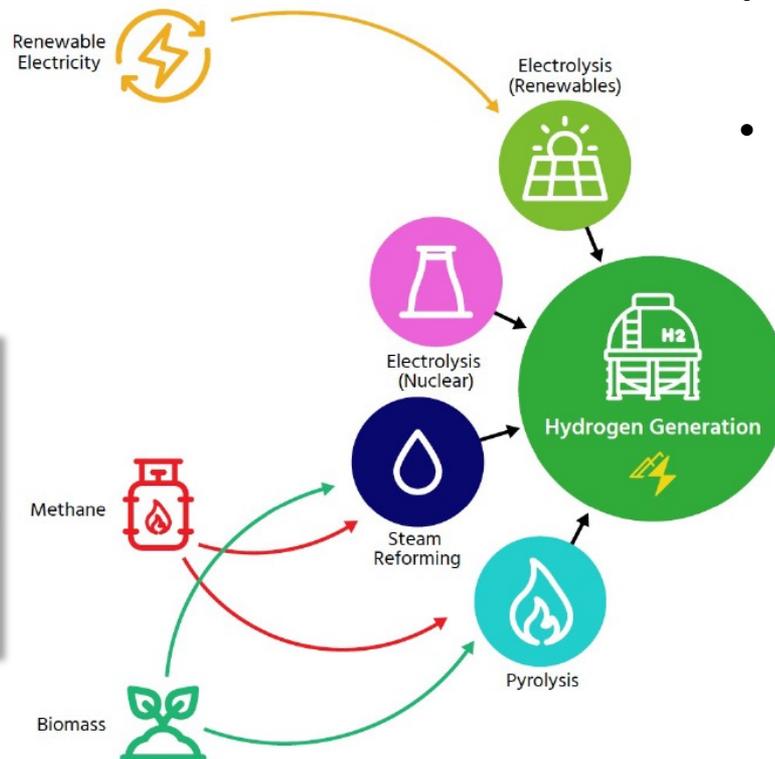
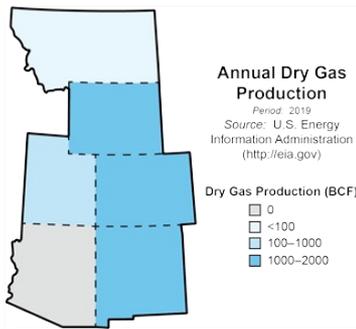
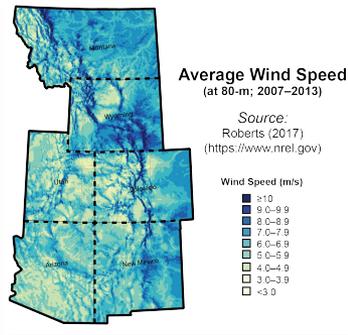
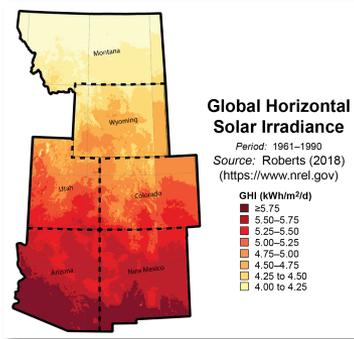


Many technology pathways to carbon neutrality in the Intermountain West will relate to a hydrogen economy.



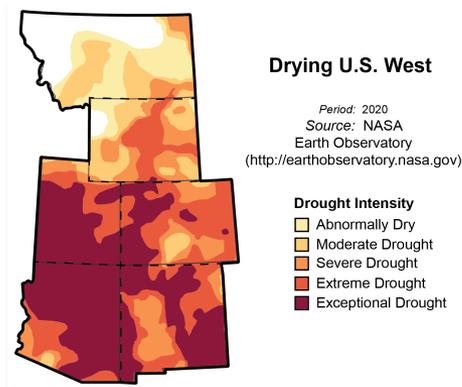
- **H₂ economy will require identifying regional options for supply and demand**
 - Workshops on generation and utilization begin in 2022
- **A spectrum of options is likely across the region**
 - Early assessment suggests several approaches to hydrogen generation may (supply) may emerge
 - Similarly, several targets for regional demand appear likely
 - Export to other regions is also a likely option to emerge—via hydrogen, ammonia, other

Several options for hydrogen generation align with regional resources.



- The region has high potential for wind and solar
- Parts of the region have natural gas resources
- High solar potential could also be tapped through biomass
- Nuclear is being considered in parts of the region

Water is an issue throughout the region, but there are opportunities to utilize “produced” water—oil/gas & CO₂.

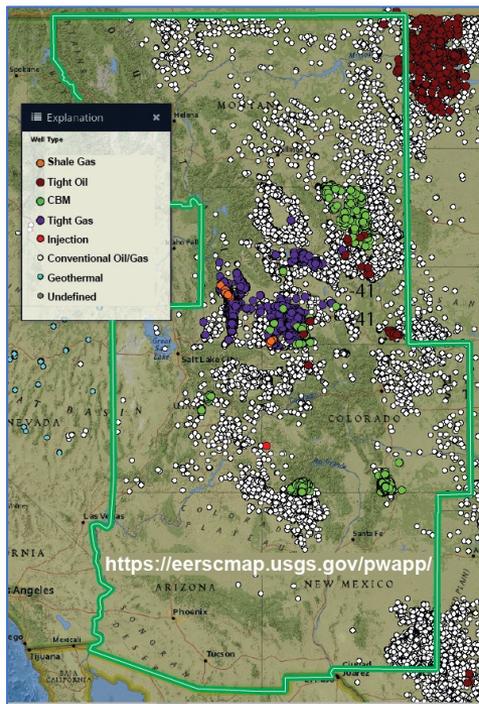
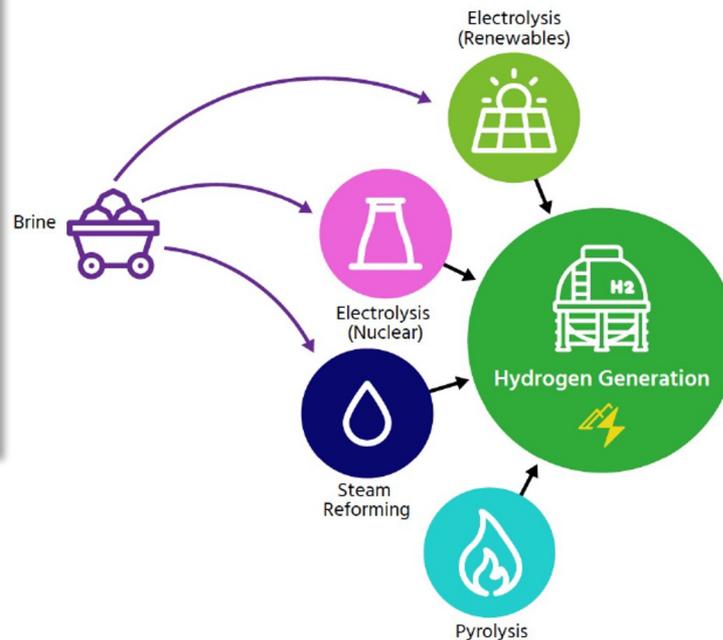


- **Different water needs for each generation pathway**

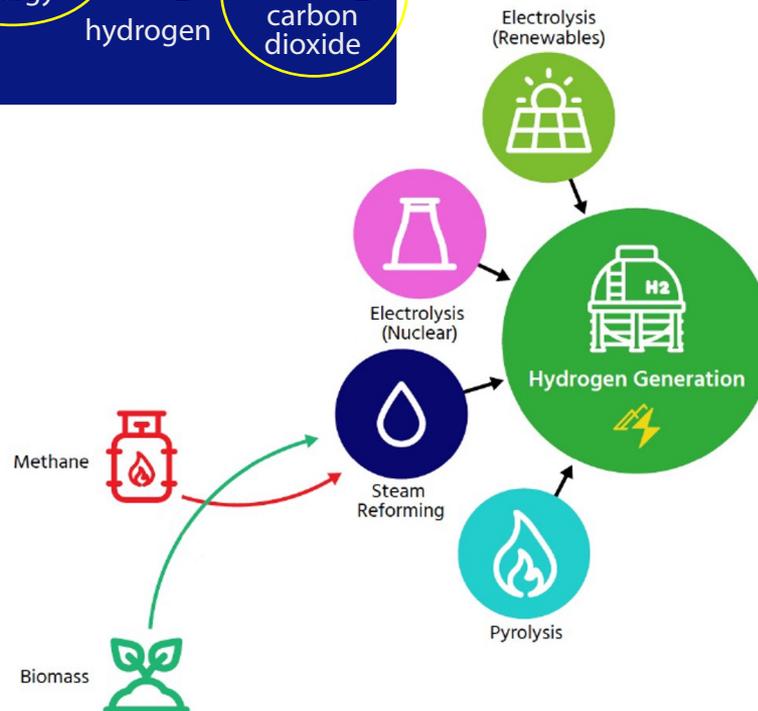
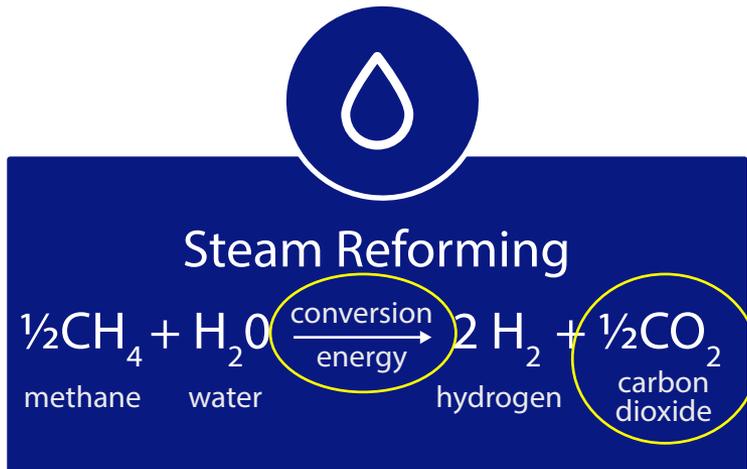
- *Electrolysis*—all of the H₂ comes from water
- *Steam reforming*—half from water, half from methane
- *Pyrolysis*—all from methane

- **Could brine be used—e.g., desalination**

- Produced water from regional oil/gas operations
- Brine co-produced during CO₂ injection



In steam reforming, capture of the produced CO₂ is integral to a regional “low-carbon hydrogen” strategy.



- For methane feedstocks, CO₂ capture is essential
- For biomass feedstocks, CO₂ capture can result in “air capture”
- **Multiple potential CO₂**
- **Fugitive methane may also be a consideration, e.g., ...**
 - Methane “hot spot” in Four Corners
 - Southern Ute field test to reduce fugitive methane emissions

What are our lessons learned, and how have we modified our approach accordingly?

- Break roadmap building into sections, starting with a focus on the FIRST 5 years
 - Initial plan was single workshop on entirety of each technology pathway
- Cost models will be important for analysis of the roadmap, but there may be a need for consensus building for some key costs
 - We are exploring holding a consensus building workshop to bring key modeling groups together to identify appropriate approach to the Intermountain West
- Electricity and natural gas are key exports from the region. What is the roadmap to evolve these to carbon-neutral “commodities”?
 - We have added “electricity” to our original plan; may add natural gas as well.
- Input from Tribal Nations is key but requires a consideration of additional factors—tribal priorities, speed of action, building trust, historical impacts, web vs. in-person
 - Personal outreach from LANL director was helpful in demonstrating commitment to I-WEST—resulted in improved workshop registration
 - Pursuing targeted tribal outreach
 - Leveraging tribal networks within LANL
 - Continued outreach throughout assessment

Opportunities for Cross-office Engagement

- Symbiotic Economies
 - CO₂ capture/use, production/use of biomass for energy, H₂ generation/use, production/distribution of low-carbon electricity
- Repurposing of Refineries
 - Explored as part of BETO workshop
- Workforce Assessment
 - Workforce considerations in equity of transition
 - Potential resource-limitations—competition among emerging projects in some categories
- Common Needs for Transition—Infrastructure and Availability of Resources
 - Interconnectivity of technologies necessitates regional-scale planning
- Cost Analysis
 - Consensus on cost models could facilitate some decisions
- Co-recovery of Water, Critical Materials, etc.
 - Offsetting benefits in region could derive from indirect ties to energy transition
- Hybrid Opportunities
 - Some potential technology pathways in region could cross offices